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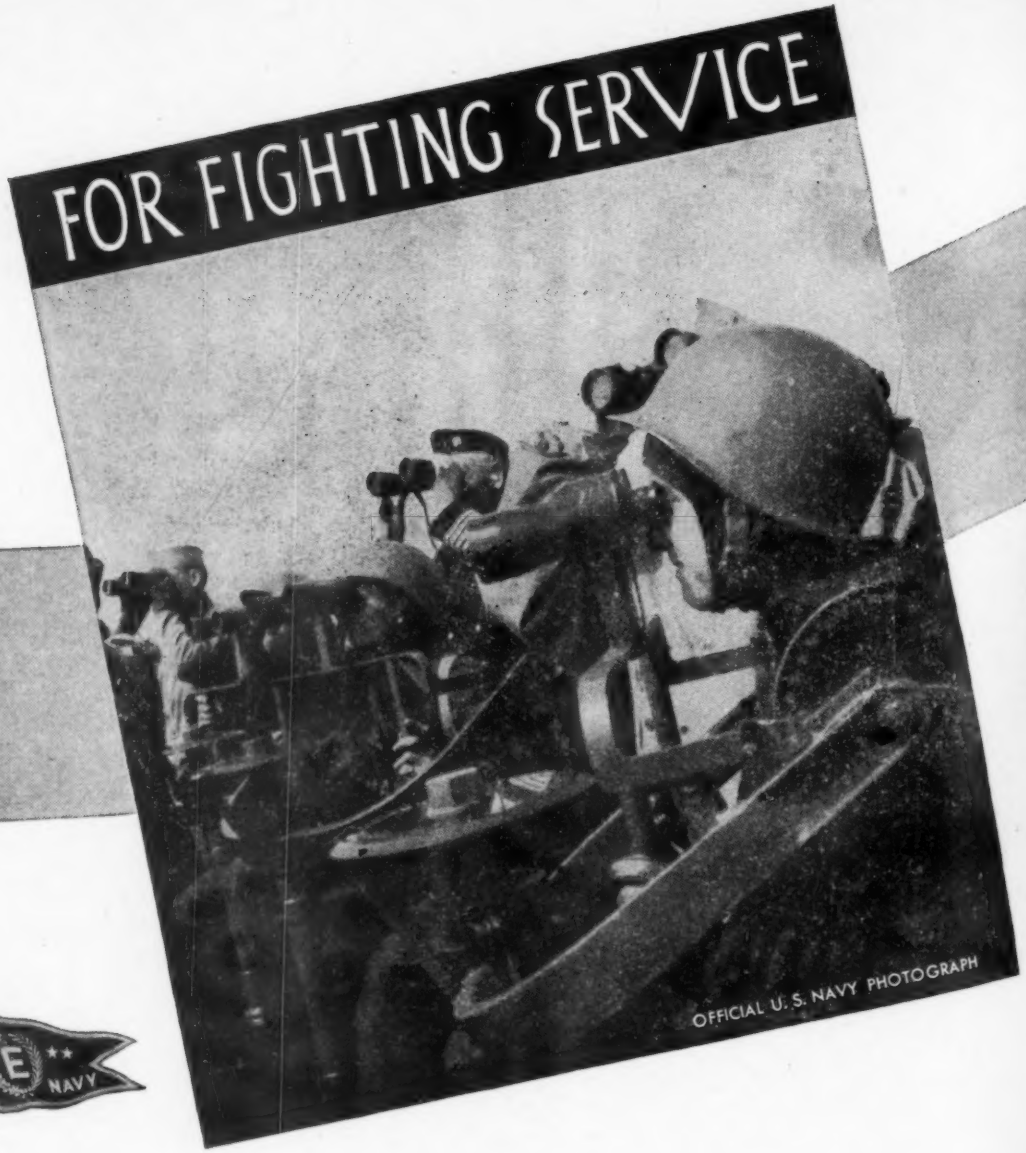

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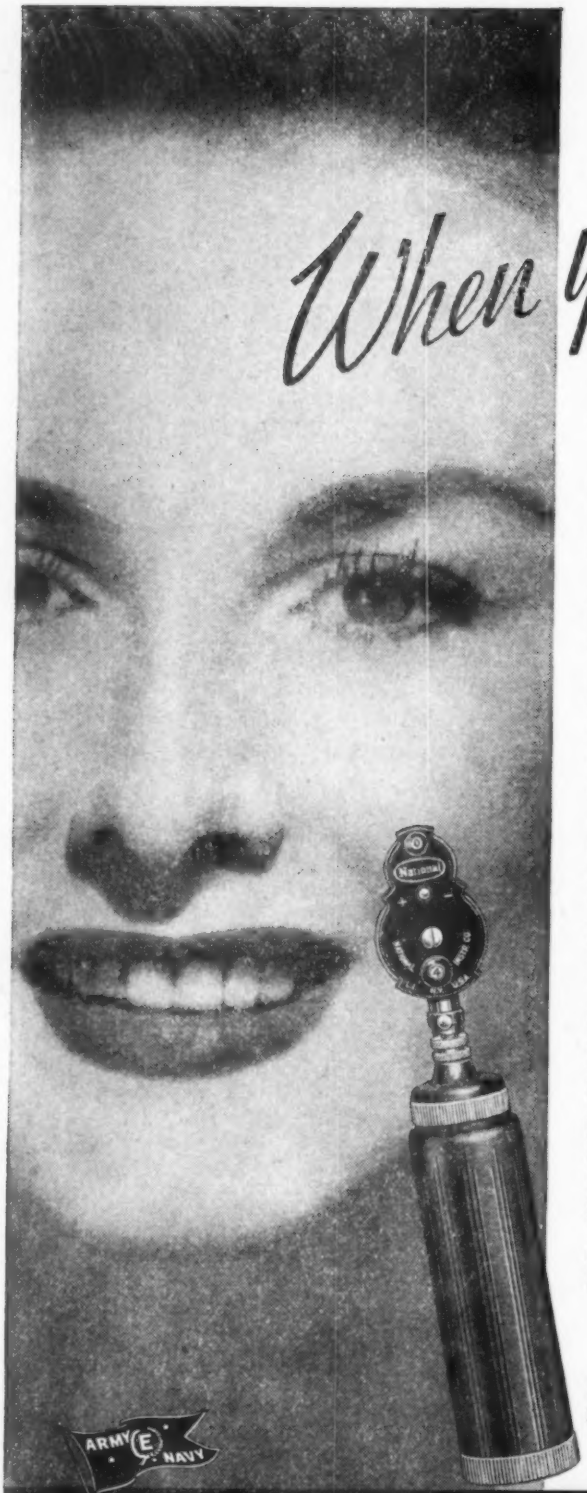

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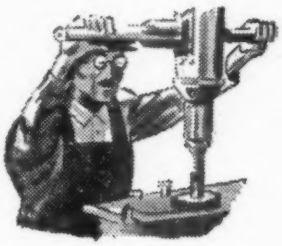

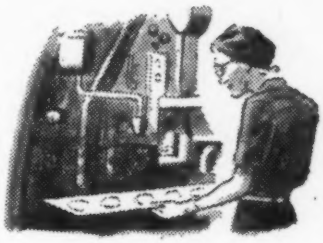

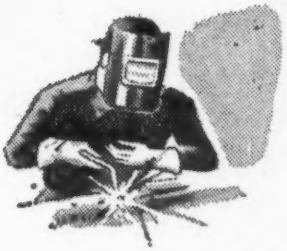

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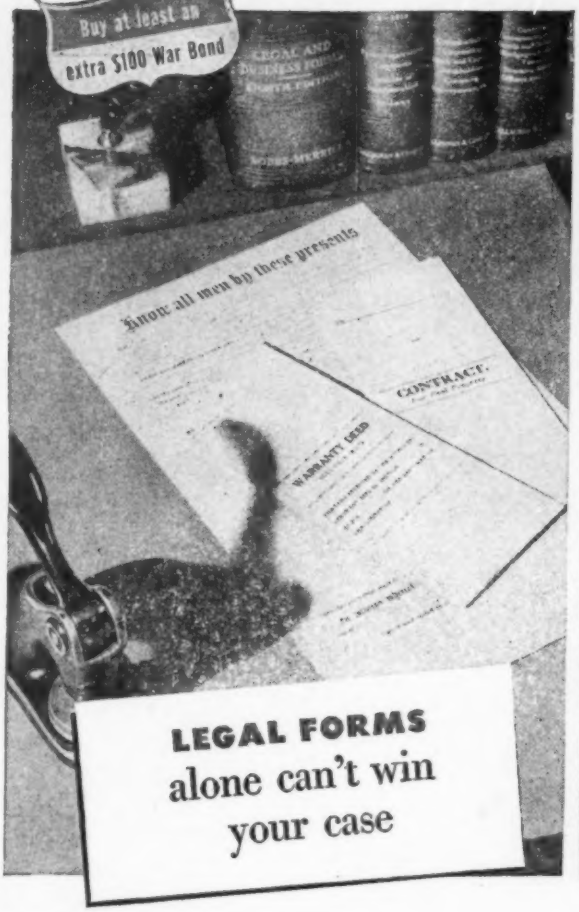

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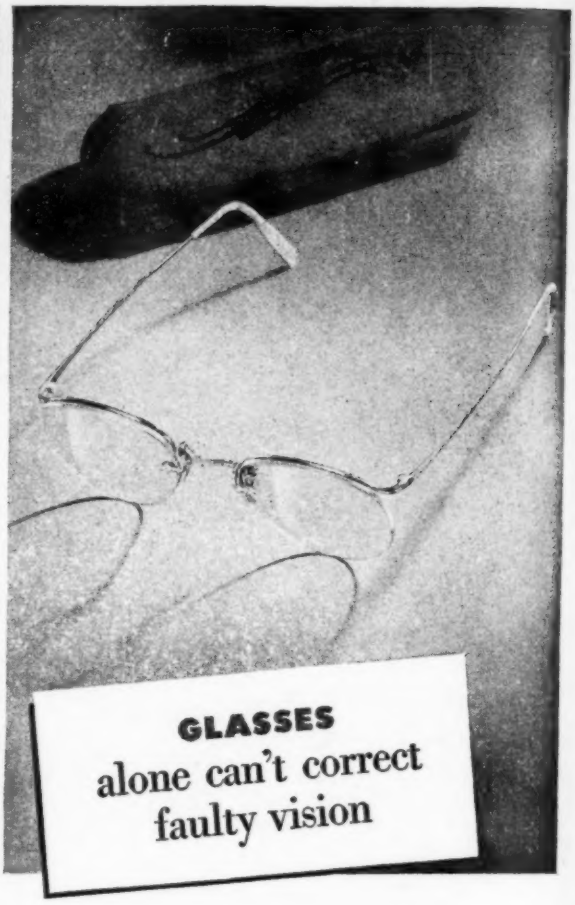

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BLOOD PRESSURE IN OCULAR WORK*

Charles A. Blind
Los Angeles, California

The unusual, the critical and the spectacular seem to be the order of the day. There is nothing ordinary about the times, and most people, including physicians, feel that this is true of all diseases and afflictions. In the field of cures (drugs, manipulation, operations, eye exercises and seeing aids), nothing short of the miraculous stays the attention of either the patient or the healer for any consideration. Creeping into this unusualness of all maladies of the flesh or spirit is the coloring of the tropics and the Orient. None of us has anything usual any more; if we have a sore throat it is some new tropical disease; irritation of the eye or lids may be one of the dreadful infections known in the Orient. The real disease with which we are confronted is the disease of the times, that is, the disease of unbalanced judgment. This disease is pandemic, affecting people rather generally and invading the halls of learning and the sanctums of the research workers. The subject "Blood Pressure in Ocular Work" is a timely one for the civilian blood pressure is certainly on the rise. With this existing turmoil it is gratifying to read a book like Irving Page's "Hypertension, a Manual for Patients," for this little book is filled with common sense and sane advice. Another excellent book that I recommend for your reading is "Arterial Tension."[1] Groups such as this Academy represents, devoted as they are to the deliberation of health problems, give reassuring evidence that islands of stabilization do exist. We hope they may have a far-reaching, stabilizing influence.

What is this thing called "high blood pressure" or hypertension?

*Presented before the Southern California Chapter of the American Academy of Optometry. Submitted on August 16, 1944, for publication in the November, 1944, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

Hypertension is a sustained increase in the pressure of the blood within the arterial system, but what causes this sustained rise in blood pressure? There are several acute toxic conditions such as acute glomerular nephritis and the acute toxemia of pregnancy which produce a high blood pressure over a period of time. When these acute conditions are corrected the blood pressure returns to normal and continues there. The experiments of Goldblatt, Lynch, Hangall and Summerville demonstrated more clearly the direct relationship of renal disease to hypertension. These experiments showed that impairment of renal circulation, even when unilateral, could be an etiological factor in hypertension, and that when the offending kidney was removed blood pressure returned to normal and remained normal. There is a condition, however, where the patient has a sustained high blood pressure without any known cause. This condition is known as essential hypertension, and is divided into two types, the malignant or fulminating type, and the non-malignant or chronic type. The malignant type is more likely to occur in the twenty to forty age groups; the younger the start, the quicker the finish.

What causes the sustained rise in blood pressure? There are several theories. One theory is that something goes wrong with the blood supply of the kidney, resulting in the liberation of a substance called angiotonin. It is believed that angiotonin circulating in the blood causes the blood vessels to constrict and stimulates the heart. The constriction or narrowing of the arterioles, as well as the increased work of the heart, leads to a rise in blood pressure. The strain of the increased pressure on the blood vessels and heart leads to arteriosclerosis and disability. What causes the kidneys to liberate angiotonin? Again there are several theories, the chief of these being the renin or extract theory, and from this theory the vaccination or injection of renin or extract for treatment has developed. There are probably several causes or a combination of causes. One combination may be the continual bombardment of abnormal stimuli. An example of physical stimulus is that of noise and glare; an emotional example is that of keeping up with the Jones', with poor nutrition which means inadequate carbohydrates, proteins, fats, vitamins and minerals. Other combinations may be strain plus focal infection, strain plus heredity, heredity and infection, et cetera.

The pressure with which the blood is propelled through the arteries is measured by the amount of pressure necessary to stop the flow of blood through the artery. It is recorded in millimeters of mercury; the systolic and diastolic pressures are measured and recorded, and the difference

between the two is the pulse pressure. All are significant; the diastolic is most important. Normal systolic pressure for a person twenty years of age is 120 mm, diastolic 80 mm, and pulse pressure 40. There is a normal rise in blood pressure both systolic and diastolic with age. The pulse pressure remains about the same. This ratio relationship is very important and a marked disturbance in it is a danger signal.

What causes an increase in blood pressure? The causes are many: some sixty-three have been named. It is perfectly normal for your blood pressure to rise under emotional strain (fear or anger), or physical exercise, but it should return to normal within a short time. It is only abnormal when it remains up and rises further from that point upon exercise or strain. The blood pressure varies normally during the day by some 20 or more millimeters of mercury. When hypertension is developed, whatever the cause, the danger will depend upon several constitutional factors which influence the strength of the vessels. These factors are heredity, nutrition and especially such factors as Vitamin C (the citrus factor), the cholin content of the body, focal infections, et cetera.

There seems to be considerable disagreement among authorities concerning diabetic retinitis or retinopathy, and hypertensive or cardiorenovascular disease retinopathy. Cambridge[2] concluded from his series of 1000 cases that it is doubtful if retinitis due to diabetes alone has ever occurred. Rosenberg expressed the opinion that from the point of view of the oculist it is wise to divide diabetes into two types, the severe diabetes of youth and the mild diabetes of old age, and he concludes that ocular complications are caused not by diabetes but by angiosclerosis. Wagner, Dry and Wilder in their series of 1052 cases found retinal lesions occurring most in patients over forty years of age, and were usually associated with hypertension or other evidence of vascular disease. However, Sanford R. Gifford makes a distinct differential diagnosis between diabetic retinopathy and hypertensive retinopathy, though in his studies he found that diabetic retinopathy is somewhat more apt to be present in diabetic patients with hypertension. McKee,[3] in reporting his findings in 2360 cases of diabetes, makes a distinct difference between diabetic and hypertensive retinopathy, though agreeing that the two conditions may be present. You may have a diabetic retinopathy which presents the following picture, or a combination of the two:

PATHOLOGY OF DIABETIC RETINOPATHY

Alterations in the vessels of the diabetic fundi affect both veins

and arteries. The first sign observed is a general congestion of the veins which results in an increase in their diameter and a broadening of their light reflex. Next, these veins being made longer by congestion show bending in the direction of the artery, and this bending may be considered a first step in the development of venous tortuosity. This predisposes to hemorrhage (venous). The retinal hemorrhages are small and deep involving the terminal arteries. The patches are small with clear cut margins and are soapy or waxy in appearance; these are grouped around the macula. The white deposits are probably best explained as being due to occlusion of the arterial limb of the capillary loops. This causes microscopic areas in which the retinal cells become necrotic. Since the retinal vessels, especially in the macula are without anastomosis such microscopic areas of necrosis become the seat of lipoid or hyaline deposits which give them their appearance.

Degenerative changes within the veins may account for thrombosis of retinal veins. These same degenerative changes may result in large preretinal hemorrhages, and hemorrhages into the vitreous occur followed by a growth of new vessels into the veils of connective tissue left by incomplete absorption of such hemorrhages. This picture is known as retinitis proliferans, and was found in 1.2% of Hanum's series, and 1.4% of those of Waite and Beetham. Less than .1% was found in McKee's series.

Diabetic retinopathy seems to be no indication as to the severity of the diabetes, but rather indicates the length of time it has existed.

PATHOLOGY OF HYPERTENSIVE RETINOPATHY

The first evidence of hypertension as seen in the ocular fundi is the narrowing of arteries (spasm), which may not be constant during the early stage of chronic non-malignant type. The eye arteries contract to keep the pressure normal in the retinal veins, according to Koch.[4] The next is evidenced in a change in caliber of the so-called spasm or atheroma, followed by tortuosity of the arteries especially peripheral, mottling of the arterial reflex; fuzzy or blurred areas in the retina indicating edema, flame-shaped hemorrhages in the nerve fibre layer, thrombosis of veins or arteries, "silver wire" arteries, arteriovenous nicking.[5] The last named is always associated with long standing or malignant hypertension with enlargement of the heart. There are different degrees of nicking. The fully developed arteriovenous nicking is accompanied by complete obliteration of the vein on both sides of the artery. Another picture that may

be presented in the fundus of the hypertensive patient is that of constricted arteries with increased tortuosity, exudate and hemorrhage. There may be edema around the disc of different degrees, from blurring of the disc to complete obliteration of the disc. In this state increased intracranial or intrathecal pressure may be found. It is at times very difficult to differentiate this condition from that presented by brain tumor.

SYMPTOMS OF HYPERTENSION

I present the following from Osler:[6] "The symptoms and signs of hypertension are variable and difficult to separate from those due to other associated conditions. In many cases there are no symptoms; the individual is in good health, and the hypertension is discovered accidentally in the course of a life insurance or check-up examination. Headache, vertigo, feeling of fullness in the head and flushing are common complaints. Severe nose bleeds often occur. The heart rate may increase or many remain unchanged. Hypertension hypochondriasis is frequent. The patients suffer more from knowing that hypertension is present than from the hypertension itself.

"As time goes on, symptoms appear referable to changes in various organs. Oftenest cardiocirculatory symptoms develop such as dyspnea and cough. Paroxysmal dyspnea, often nocturnal, may occur as isolated attacks. Attacks of angina pectoris and cardia infarction are prone to happen. Later on cardiac symptoms and signs increase until there is cardiac decompensation. Nausea, vomiting, diarrhea point to changes in the gastro-intestinal blood supply. About 60% of the patients die of congestive heart failure or cardiac infarction (coronary). Cerebral vascular accidents or encephalopathy come to about one-fourth of the patients. In 5 to 10% renal insufficiency develops, often to progress into uremia.

"The physical findings may show only high pressure, and in temporary cases there may be nothing more. Usually changes in the arteries are evident. (This is especially true of the retinal vessels.) Cardiac hypertrophy usually is present. (In this case there will be a nicking of the retinal veins.)

"In the so-called malignant hypertension there are severe headache, often great loss of weight, marked retinal changes, marked hypertension with diastolic pressure much increased and a progressive course. The duration is about two years, but may be less. Diastolic pressure is proportionately high and fluctuates very slightly, if at all. Malignant hyper-

tension is an undesirable term. It is not a definite pathological condition but is only a severe grade of hypertensive vascular disease in which renal involvement is usually markedly developed.

"The prognosis depends principally on the cause and the extent of disease in the circulatory and renal systems. Marked increase in the diastolic pressure generally is of serious significance. The long duration of life in some patients with hypertension should be kept in mind always."

Besides the types of hypertension already mentioned, there are the following:

1. Postural Hypertension. In some patients blood pressure is higher in the erect than in the recumbent posture of the patient, with some cardiac and cerebral symptoms. To test this readings are made when the patient is ambulatory and after one or two days strictly recumbent in bed. If the latter lowers pressure pyelograms are made in the erect and recumbent positions. These show nephroptosis and lower diotrast clearance in the erect position suggesting that nephroptosis elevated blood pressure by causing renal ischemia. Corsets with pads to hold up the kidney either lowered pressure or, without changing it, lessened symptoms. This method failing, nephropexy might be tried.[7]

2. Paroxysmal Hypertension. This is an unusual, but very striking clinical syndrome. It is caused in the majority of cases by a neoplasm of the adrenal, which periodically excretes a highly potent substance greatly and rapidly elevating the blood pressure. Excision of the neoplasm cures the condition. Not all cases, however, are caused by neoplasm. Similar paroxysms have been noted in cases of hypertension. Blood pressure is usually normal between paroxysms caused by neoplasm.

The symptoms and signs of paroxysmal hypertension are abrupt in onset. A sensation of fullness or choking in the neck, substernal oppression or pain, epigastric distress, Raynoud disease types of angiospasm of extremities or nose tip, sweating, epiphora, pallor, nervousness, tremor, muscle weakness, palpitation, headache, nausea, vomiting, vertigo, convulsive seizures, tinnitus, air hunger, turgor of neck veins, abdominal colic and diarrhea are some of the symptoms and signs which in varying proportion make up the paroxysms. Blood pressure, both systolic and diastolic, rises to great heights, pulse may be slow or rapid and bounding in quality. Albuminuria, glycosuria and hyperglycemia occur. Exercise,

body flexion or blow on the abdomen may start a paroxysm. Later on, in some cases, hypertension becomes persistent.

When death occurs from hypertension it is most commonly the result of myocardial failure; second most commonly the result of cerebral vascular accidents and third most commonly the result of renal insufficiency.

The retinal changes which are seen in different hypertensive patients have been divided into four groups:[8] (1) Evidence of retinal arteriolar spasm without organic change. (2) The combination of retinal arteriolar spasm and retinal arteriosclerosis, the latter being an irreversible process. (3) The existence of retinal arteriosclerosis plus definite retinitis which is characterized by the presence of hemorrhages and exudates. (4) The existence of retinal arteriosclerosis, retinal hemorrhages and exudates plus edema and elevation of the optic discs. If hemorrhage and exudate involve macular region there may be considerable impairment of vision. Occasionally even in the presence of milder types of retinitis sudden hemorrhage into the vitreous may occur with loss of vision and in other cases acute thrombosis of retinal arteries or veins may result in sudden partial or complete blindness. Many of these retinal vascular lesions cause permanent retinal damage.[9] The severity of hypertensive disease and therefore the progress often may be determined with reasonabl accuracy on the basis of the type of lesion seen in the retina. Thus the prognosis is reasonably good in those cases in which there is no retinitis, whereas when retinitis is present the prognosis is rather grave.[10] When both retinitis and edema of the discs are present, the prognosis is definitely bad and few patients so affected live longer than eighteen months after this observation has been made.

HYPOTENSION

A persistent systolic figure below 110 may be regarded as hypotension, but hypotension is not a disease. There are three main groups (the fourth named could be a part of group two, or may be given a fourth position):

1. Essential or Primary Hypotension
2. Secondary Hypotension
3. Postural Hypotension
4. Relative Hypotension

1. Essential or Primary Hypotension (a) patients who appear in every way entirely normal but who have blood pressure well below,

sometimes far below, the figures assigned for normal. These people seem to have a longer life expectancy than those with so-called normal pressure; (b) patients with symptoms ascribed to low blood pressure but for which no cause can be found.

2. Secondary Hypotension. (a) Weakness of left ventricle; (b) vasomotor disturbance; (c) some cases of arteriosclerosis; (d) anemia; (e) hemorrhage, severe diarrhea; (f) endocrine gland disturbances (adrenal insufficiency—hyperinsulinism); (g) cachexia and malnutrition; (h) shock; (i) circulatory failure of infectious diseases; (j) certain individuals with constitutional infirmity—this group belongs in the postural type.

3. Postural Hypotension.[11] Man would have syncope while standing upright if it were not for certain adaptive mechanisms which tend to maintain a constant cerebral blood flow. In the standing position the amount of blood present in the upper part of the body is decreased, first because the vascular bed in the portion of the body below the heart is dilated by a high hydrostatic pressure and, second, because the high capillary pressure causes an increased filtration of fluid from the blood stream and a decrease in plasma volume. This decrease in blood volume in the upper part of the body is compensated for by vasoconstriction and by increase in heart rate. There is a group of individuals in whom this compensating mechanism fails to function properly and adequately. These people may have a normal blood pressure when in the recumbent position but it falls below normal in the upright position. The extent of the fall varies in different individuals and the symptoms vary accordingly. These are classed as Postural or Orthostatic[12] types of hypotension. Heredity and physical makeup play an important part in this type. Orthostatic circulatory insufficiency[13] may be a feature of Addison's disease. It is remarkable and perhaps not generally known that Addison mentioned orthostatic weakness and syncope in his first report.

4. Relative Hypotension. These are cases which normally carry such a high blood pressure that even though they suffer a considerable lowering of blood pressure by shock, anemia, acute disease, diarrhea, et cetera, their blood pressure may still register above the accepted normal. These patients will nevertheless have symptoms of hypotension until this relative lowering in blood pressure has been corrected. The sympathetic nervous system plays an important part both in hypertension and

in hypotension. Therefore, any condition of environment or any therapeutic agent which normalizes the autonomic nervous system tends to or does normalize the blood pressure. Prominent in these corrective agencies are corrective lenses for the relief from abnormal bombardment stimuli, and osteopathic manipulative spinal treatments for the relief of spinal tension, thereby normalizing the nutrition to and removal of waste from the autonomic as well as the cerebrospinal nervous systems.

SYMPTOMS OF HYPOTENSION[14]

Symptoms most frequently attributed to essential hypotension are lassitude, dizziness, headache, lack of stamina, nervousness and cold extremities. Yet all persons with hypotension do not have these complaints and many are robust. The person with symptomatic hypotension, however, is notable because of his habitus and general condition. Characteristically he is of linear build, is underweight, affects sedentary habits and takes little exercise. Nervous instability is frequent and the body temperature tends to be subnormal. This presents the problem of whether symptomatology is due to hypotension, or whether both symptomatology and hypotension are due to habitus and physical condition.

The symptoms of secondary hypotension can not usually be differentiated from the symptoms of the causative factors, anemia, shock, hemorrhage, et cetera.

The symptoms of postural hypotension are syncope, dizziness or dimness of vision. The significant finding is a marked drop in blood pressure which occurs when the patient assumes the standing position or when he has been standing quietly for several minutes; some present associated tachycardia. Fluoroscopy with the patient upright will disclose a small, droplet type heart. Electrocardiograms taken with the patient standing often reveal inverted T waves in leads II and III. These revert to normal with recumbency. In diagnosis, neurologic disease such as tabes dorsalis and multiple sclerosis should be ruled out.

Whereas in hypertension many changes take place in the eye and the progress and severity of the hypertension can often be determined by conditions found in the retina, in hypotension there are no ocular changes. The vision is at times very markedly disturbed, but there are no objective manifestations. The decrease in vision in hypotension is due to the inadequate circulation. This inadequacy is responsible for

faulty nutrition to the retina and faulty Vitamin A replacement of the visual purple. In all types of hypotension the visual acuity varies from time to time because the blood pressure and therefore the nutrition of the retina varies from time to time. This variation comes particularly in the orthostatic type with change of position, and in this type of hypotensive patient the visual acuity should be best when he is in a recumbent position. In all types of hypotension the hypotensive state varies with the general condition of the patient and improves with general nutrition. It is especially affected beneficially by moderate exercise, and since a high percentage of hypotension cases are in sedentary occupations, the vision of these patients could be expected to improve in certain times of year (i.e. summer and vacation time), when there is a tendency to get more exercise. As you all know, this variation in vision is most disturbing to anyone trying to make an optical correction of errors of refraction. The manifest method of refraction is especially vulnerable to these variations. Though the vision and the reaction of the patient to his glasses may vary with the change in blood pressure, the actual error of refraction does not change and properly fitted lenses should be the best obtainable for the patient when he is in a poorer or in an improved state of health. Naturally, the vision will be less satisfactory when the health is poor than when the health is good. If you are accurate in your ocular measurements there should be no need for change of lenses with the change of blood pressure, but there is a very definite need for a proper understanding by the patient of his problem. He is due an explanation of his difficulty and he should be made to realize that he must expect this change in visual acuity as long as a considerable change in blood pressure occurs.

The most satisfactory treatment for both essential and postural hypotension is removal of enervating mental and physical stimuli, properly regulated exercise and diet, and avoidance of long periods of standing immobile. In postural hypotension added benefit is derived from abdominal supports and sleeping with head of the bed elevated 18 inches.

The drug of choice for essential and postural hypotension is paradrine hydrobromide. Its action is seemingly confined to the peripheral sympathetic mechanism and it does not have the cerebral stimulating effect or produce insomnia as does ephedrine sulfate and amphetamine sulfate. Sex hormone therapy is indicated in some cases.

The treatment of secondary hypotension is the treatment of the causative factor, and may include the entire practice of the healing art in all of its ramifications, for the causative factors are legion.

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THE "PSYCHOPHYSICS OF COLOR" FROM THE COLORIMETRY REPORT OF THE OPTICAL SOCIETY OF AMERICA*

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In the development of a quantitative psychophysical science of color, the concepts of light and of color need be defined only by the procedures which are prescribed for their measurement. Such operational definitions are difficult to express concisely; consequently relational definitions are desirable in order to clarify the sense in which the words should be used. Such definitions can be formulated by stating the distinctions between these concepts, light and color, and the concepts related to them in the fields of psychology and physics. Light and color are psychophysical concepts according to both the relational and the operational definitions. These definitions are equivalent in significance, although the first type is most useful for guidance as to the correct use of the terms in general discussions and the second is essential for the precise definition of the concepts with which the measurements are concerned. The relational definitions are expressed in general terms, rather than in terms of quantitative concepts. The use of quantitative concepts would specialize the relational definitions in an undesirable manner.

DEFINITIONS OF LIGHT

The relations between radiant energy, light, and visual sensation can be defined in the following generalized and qualitative manner:

Light is the aspect of radiant energy of which a human observer is aware through the visual sensations which arise from the stimulation of the retina of the eye.

Light as thus defined is a psychophysical concept. Light is not identified with either radiant energy or with visual sensation. Light is one of the many conceivable aspects of radiant energy. The photographic effectiveness, the radiometric power, and the erythemal potency are

*For a number of years the Colorimetry Committee of the Optical Society of America has been working on a report designed to bring order into the definitions and concepts of color, and to provide useful data. The Society expects to publish the entire report in book form when completed. This portion of the material, which is greatly abridged, will appear in Chapter VI of this book. It is suggested that the reader refer to "The Historical Background and Evolution of the Colorimetry Report of the Optical Society of America" by Lloyd A. Jones, published in the August, 1944, issue of this journal. This present section of the report is an abridgment of the material which appeared in the Journal of the Optical Society of America, Vol. 34, No. 5, pp. 245-266, 1944.

examples of other aspects of radiant energy. Light, however, is the aspect of radiant energy of which human observers are aware through the immediate agency of the eye and the sensations and perceptions resulting from the stimulation of the retina. The concept of light is not limited to the quantitative aspect of radiant energy, because human observers are aware of more than just the quantitative aspect, which corresponds only to the brightness attribute of visual sensation. Light has many characteristics, only one of which is included in the specialized concepts of the quantity and flux of light. For instance, light may have, and usually has, the characteristics of non-uniform spatial distribution and of temporal fluctuations. In the following discussion reference to these characteristics will be made by use of the more concise phrase, "spatial and temporal inhomogeneities." In addition to these, light has characteristics which are referred to collectively as color. The quantitative characteristic of light is one of the characteristics included in the concept of color. Two other characteristics of light, which may be specified in terms of dominant wave-length and purity, are included also in the concept of color. Patterns of colors arise from non-uniform spatial distributions of light. Spatial non-uniformities and fluctuations of light result in the successive appearance of different colors and are not included among the characteristics which constitute color.

The evaluation of luminous flux originated before the precise evaluation of the other color characteristics of light was proposed. Consequently, the definition of this quantitative concept preceded, and was to a great extent independent of the definition of color. Therefore, although luminous flux is one of the characteristics of light used in defining color, it is possible, expedient, and, in fact, customary, to define luminous flux without reference to color. Luminous flux is the time rate of flow, emission, or incidence of light. In the sense required by this definition of luminous flux, light is the evaluation of radiant energy in terms of its capacity to produce the brightness attribute of visual sensation. This brightness-producing capacity of radiant energy is expressed in terms of luminous energy, in units of lumergs or talbots. Various origins and manifestations of luminous flux are expressed in terms of luminance, illuminance, luminous emittance, or luminous intensity.

DEFINITION OF COLOR

Color consists of the characteristics of light other than spatial and temporal inhomogeneities; *light being that aspect of radiant energy of*

which a human observer is aware through the visual sensations which arise from the stimulation of the retina of the eye.

Color as thus defined is a psychophysical concept. Color is not identified with radiant energy nor is it identified with sensation. The characteristics of light which constitute color can be specified in terms of: (1) the appropriate photometric quantity, (2) dominant wave-length, and (3) purity. In a general way these characteristics of light correspond to the attributes of visual sensation: brightness, hue, and saturation. (Luminance corresponds most directly with brightness, yet other photometric concepts—illuminance, luminous intensity, and luminous flux—are also related to brightness under certain conditions.) Rarely, if ever, is light temporally constant or spatially uniform throughout the entire field of vision. Nevertheless, in accordance with this definition of color, the light from each portion of the field which is uniform and constant during an appreciable time has a definite color.

COLORS ASSIGNED TO OBJECTS

According to a strict interpretation of the definition of color given in the preceding section, it is not legitimate to attribute colors to objects, but only to the light reflected from them. Insofar as an object can be said to have a color, its color consists of the capacity of the object to modify the color of the light incident upon it. This capacity depends upon the variation of absorptance for various wave-lengths. When the absorptance varies with wave-length, the object is said to exhibit *selective absorption*, that is, the variation of absorptance with wave-length. In this sense, the color of an object may be considered to be a consequence of selective absorption, but color should not be considered synonymous with selective absorption. In addition to depending upon selective absorption, the color of an object depends upon the spectral distribution of the incident radiant energy, and *upon the psychophysical functions of human vision.*

There is no unique color of an object, since, among other things, the color depends upon the quality and intensity of the incident radiant energy. However, the color of the light reflected from an object in its most customary illumination (e.g., daylight or incandescent lamp light) is so familiar that it is usually considered to be the color typical of the object. In accordance with this practice, the luminous reflectance (or luminous transmittance) of the object, and the dominant wave-length and purity of the reflected light are considered to be charaeteristics of the object. These characteristics constitute the color assigned to the object.

Those varieties of light which are occasionally called "colorless" have a color according to the usage recommended here, the purity of the color of neutral or "white" light being zero and the dominant wave-length being indeterminate. By extension of the concept that photometric quantity is one of the color characteristics of light, a dark object is considered to have a color different from light objects. This usage also eliminates the necessity for the phrase "light and color" which would be necessary if photometric magnitude were not one of the characteristics of light included in the concept of color. Photometry, the science of the measurement of the quantitative aspects of light, is thus included in colorimetry, the science of color measurement. It is not necessary to say that colorimetry is the science of the measurement of light and color, since the evaluation of the photometric magnitude, which is the measurement of one characteristic of light, is part of the measurement of color.

Colorimetry carries over the usage adopted in photometry by employing the concept of luminous reflectance (and luminous transmittance) as the most appropriate measure of light reflecting (or transmitting) efficiencies of objects. Luminous reflectance and transmittance, as well as dominant wave-length and purity of the colors attributed to objects, are dependent upon the spectral distribution of the incident energy. The term spectral distribution here refers only to the relative values of the energy per unit wave-length interval at every wave-length. The absolute values are referred to by the term spectral composition.

CHROMATICITY

The term chromaticity refers to the characteristics specified by dominant wave-length and purity. Any psychophysical specification of color which embodies the same information as dominant wave-length and purity, but not photometric magnitude, is a specification of chromaticity. The measurement of color may be divided into two general problems: first, the measurement of luminance (or other appropriate photometric magnitude) and, second, the measurement of chromaticity. A diagram in which each point represents the chromaticity, independent of luminance of a color, is called a *chromaticity diagram*. This is a modification of the usage recommended in the 1922 report, in which the word chromaticity referred jointly to the subjective hue and saturation attributes of color sensation. The term *chromaticness* is now proposed for use with reference to these subjective attributes. This change is recommended because the need for and lack of a term referring to dominant wave-length and purity jointly has occasioned widespread usage of the word chromaticity in this sense. The substitution of "chromaticness" for use

in the subjective sense is consistent with the reservation of the suffix "-ness" for terms descriptive of subjective phenomena.

LUMINOSITY

The measurement of luminance (and other photometric quantities which are related to the brightness attribute of visual sensation) is based on the acceptance of certain data which are frequently called "visibility" data. The term "luminosity" has superseded the word "visibility" by action of all of the authoritative bodies which were responsible for the adoption of the latter term. These include the Illuminating Engineering Society, the International Commission on Illumination, and the Advisory Committee on Photometry of the International Committee on Weights and Measures. The decisions of the two international bodies were made at meetings in 1939 and, consequently, formal publication has been delayed on account of the war.

It is evident from visual examinations of the spectrum of any source (such as the sun), which radiates approximately equal amounts of energy per unit wave-length interval throughout the visible spectrum, that equal amounts of energy of different wave-lengths do not produce visual sensations having equal brightness. A luminosity curve shows as ordinates the capacities (reciprocals of the required radiance) of radiant energy of the various wave-lengths to evoke for a particular observer visual sensations of equal brightness. Although the luminosity curve may be considered to represent the response of the visual receptors to spectral stimuli, this response cannot be measured directly in a manner analogous to the measurement of the response of a photoelectric cell. Some indirect method must be employed for the determination of the luminosity curve.

DETERMINATION OF LUMINOSITY DATA

The standard luminosity data represent the concordant results of several methods of heterochromatic photometry. The cascade, or step-by-step method of heterochromatic photometry employs a photometric field divided into two adjacent areas which can be irradiated with radiant energy from separate sources. One part of the field may be irradiated so as to produce a known radiance of homogeneous radiant energy of known wave-length. The other part of the field may be irradiated with homogeneous radiant energy having a slightly different wave-length. The radiance in the second half of the field may be adjusted until the visual difference in appearance between the two part-fields is minimized. The visual difference in appearance can be completely eliminated only if the difference between the two wave-lengths is made sufficiently small.

Usually it is not necessary to use wave-lengths so close together, and frequently it is inconvenient to use such small wave-length intervals. The reciprocal of the ratio of the radiance necessary for the minimization or elimination of visual difference between the two fields is the ratio of the ordinates of the luminosity curve for the two wave-lengths. The cascade method consists of comparing in this manner one wave-length with a second neighboring wave-length, then comparing the second with a third, then the third with a fourth, progressing in this way throughout the spectrum until all the ordinates of the relative luminosity curve have been determined for the observer.

Other methods, notably flicker photometry, may also be used for the determination of luminosity data. In the flicker photometer method two homogeneous radiant energies, which may be widely different in wave-length, are presented alternately to the eye at such a rate that, although the differences of chromaticity cannot be detected, the brightness differences can be appreciated as a flicker. When the radiances have been adjusted to eliminate (or minimize) the flicker, their ratio is the reciprocal of the ratio of the corresponding ordinates of the luminosity curve. Experiments with the same observer, employing certain standard conditions of observation in both methods, demonstrated that under certain conditions the step-by-step method and the flicker photometer method yield concordant luminosity data.

DEPENDENCE OF LUMINOSITY DATA ON CONDITIONS OF OBSERVATION

The curve obtained by the use of either of these methods applies only for the conditions of observation employed during the measurements.

The comparison of curves indicates the type and degree of variation of the luminosity curve which can be expected to result from changes in the conditions of observation.

INDIVIDUAL VARIATIONS OF LUMINOSITY DATA

Even with carefully chosen and controlled conditions of observation, the luminosity curve obtained for each observer differs more or less from the curves of other observers. Except for that small but not negligible part of the population whose color vision can be classified as anomalous, most people are remarkably similar with respect to their abilities to see and to distinguish colors. It might be expected that all such individuals would require the same relative radiances in luminosity determinations and that they would therefore have the same luminosity

curve. The results of a large number of such measurements do not fulfill this expectation.

STANDARD LUMINOSITY DATA

On the basis of a comparison of their results with the results obtained by previous investigators, Gibson and Tyndall recommended for adoption a particular set of luminosity values. These values were adopted by international agreement in 1924 at the Geneva meeting of the International Commission on Illumination. The adoption of these data was an arbitrary procedure, since somewhat different data would have been obtained with another group of observers, and different conditions of observation would have resulted in different data even with the same group of observers. No one curve can represent the response of any eye under all conditions of vision. No average of a finite number of luminosity curves can be proved to be the exact average for the whole population. The particular data which have been standardized probably differ less seriously from the data for an observer selected at random than would any other arbitrarily selected set of data. The importance of the standard luminosity data is that these particular values have been accepted internationally and may be used to establish the photometric quantities by definition. Thus defined, these photometric quantities have meaning even when the conditions of observation are not standard. The direct correlation of these photometric quantities with the brightness attribute of visual sensation is not assured unless the standard conditions of observation are fulfilled and when the observer has a luminosity curve indistinguishable under these conditions from the standard luminosity curve. The utility of these quantities, even when any or all of these conditions are not fulfilled, lies in the fact that the adoption of a standard luminosity curve for general use is the most convenient basis of general agreement concerning photometric concepts. In practice, it is customary not to limit the use of the standard luminosity data to problems involving photopic (daylight and normal reading) conditions, though it is probable that we should look forward to the ultimate establishment by international agreement of standard luminosity data for scotopic (extremely low) luminances and for the intermediate (mesopic) luminances corresponding to a transition from photopic to scotopic vision. It is well known that application of photopic luminosity data to the scotopic state of adaptation gives results very noticeably inconsistent with visual observations, and for some problems, such as the photometry of luminescent and phosphorescent materials, supplementary alter-

nate procedures are being devised. The complications introduced by these alternate procedures may, however, be expected to limit their use.

LUMINOSITY: RELATIVE LUMINOUS EFFICIENCY

This efficiency will be called the *luminous efficiency* of radiant energy. Energy is not the most suitable quantity with which to discuss the correlation with brightness. The brightness produced depends not upon the amount of energy incident upon the retina, but rather upon the time rate at which it is incident upon a unit area of the retina. Thus brightness is determined by the irradiance of the retina. The standard metric unit of irradiance is a watt per square meter.

In attempting to choose a unit for the expression of the brightness-producing capacity of radiant energy, we encounter the difficulty of measuring sensation. Whether or not it is possible to measure sensation, the fact remains that up to the present time no methods or unit for the purpose have been generally accepted. We are forced, therefore, to turn to the psychophysical correlate of brightness, which is retinal illuminance. The standard metric unit of illuminance is a lumen per square meter. This unit has been named the *lux*. The luminous efficiency of radiant energy can therefore be expressed in terms of lumens per watt, the units of area common to the unit for retinal illuminance and irradiance cancelling when the ratio is taken.

ABSOLUTE LUMINOUS EFFICIENCY OF RADIANT ENERGY

The photometric and radiometric units of flux, lumens and watts, have been standardized independently of each other. The standardization of the relative luminosity data represented by curve permits the calculation of the most probable value of the maximum luminous efficiency of radiant flux, 650 international lumens per watt of radiant flux having the wave-length 555 mμ. If each of the ordinates of the standard luminosity curve is multiplied by 650, the resulting values are the luminous efficiencies of radiant flux of the corresponding wave-lengths. The curve representing these results may be called the absolute luminosity curve for radiant flux. The ordinates are lumens per watt, with the maximum value of 650 international lumens per watt at the wave-length 555 mμ.

Both the standard luminosity curve and the absolute luminosity curve are commonly interpreted in either of the following two manners:

(1) Descriptive of a property of the eye, they both indicate the spectral distribution of retinal brightness sensitivity.

(2) Descriptive of a property of radiant flux, they specify in rel-

ative and absolute terms, respectively, the spectral distribution of luminous efficiency.

It is the purpose of this report to emphasize that the luminosity function, and also the similar colorimetric functions, are not properly described in either of the above manners, but that they are psychophysical functions, medial in nature between psychological functions (as implied by 1) and physical functions (as implied by 2).

It is recommended that luminosity be defined as the equivalent of the phrase, luminous efficiency of radiant energy, in either relative or absolute values according to the context. The standard symbol for the absolute values of luminous efficiency will be K.

LUMINOUS FLUX

When radiant flux is evaluated with respect to its capacity to evoke the brightness attribute of visual sensation it is called luminous flux, and this capacity is expressed in lumens. Curves showing the spectral distribution of luminous flux from various sources have frequently been called the luminosity curves of the sources. This use of the word luminosity is inconsistent with the definition of luminosity now recommended. The ratio of the total luminous flux to the total radiant flux from a source (expressed in lumens per watt) is the luminosity K, or luminous efficiency of the radiant flux from that source.

LUMINOUS ENERGY

The concept of luminous energy, which corresponds to radiant energy, is rarely used explicitly although it is the most appropriate measure of the economic value of light. The c.g.s. unit of luminous energy is the lumerg. One erg of radiant energy having a luminous efficiency of K lumens per watt constitutes K lumergs of luminous energy. The m.k.s. unit of luminous energy, the talbot, is ten million lumergs. One joule ($=10^7$ ergs) of radiant energy having a luminous efficiency of K lumens per watt provides K talbots of luminous energy, and a luminous flux of one talbot per second is one lumen.

LUMINOUS DENSITY

Luminous density is the luminous energy contained in a unit volume of space, analogous to radiant density, and may be used in discussions of illumination problems in the same manner as radiant density is used. The c.g.s. unit of luminous density is the lumerg per cubic centimeter. The m.k.s. unit is the talbot per cubic meter. The luminous density is K times the radiant density expressed in the corresponding units.

LUMINOUS INTENSITY

Luminous intensity is expressed in candles. A luminous intensity of one candle produces one lumen of luminous flux through an area subtending a solid angle of one steradian measured from the source. The luminous intensity of a source is K times the radiant intensity expressed in watts per steradian. The concept of luminous intensity, like radiant intensity, applies only to sources that are negligibly small compared to the distance traveled by the emitted flux.

LUMINANCE

Luminance is luminous flux (lumens) per unit solid angle emitted per unit projected area of the source. A perfectly diffusing surface is one for which luminance is independent of direction of observation. The intensity (lumens per unit solid angle, or candles) of a perfectly diffusing plane source is therefore proportional to the cosine of the angle between the perpendicular to the surface of the source and the direction of observation. A convenient unit of luminance is the candle per square centimeter of projected area.

LUMINOUS EMITTANCE

The luminous emittance of a surface is the total luminous flux emitted per unit area of the surface.

ILLUMINANCE

Illuminance is the luminous flux incident per unit area of a surface. Illuminance is the product of the irradiance of a surface and the luminosity K of the energy with which the surface is irradiated. This quantity has been commonly called "illumination" in the past. The m.k.s. unit of illuminance, named the *lux*, is equal to one lumen per square meter. This unit is also known as the "meter-candle." The "footcandle" is the English unit of illuminance and is equal numerically to one lumen incident per square foot.

RETINAL ILLUMINANCE

Retinal illuminance has already been mentioned as the psychophysical correlate of brightness. The irradiance of the fovea of the schematic eye specified by Helmholtz is 0.3267 times the product of the square of the diameter (in centimeters) of the entrance pupil of the eye and the radiance of the object imaged on the fovea. Substitution of the photometric equivalents for the radiometric quantities involved reveals that, ignoring losses by reflection and absorption, the foveal illuminance (in lux) is 1.04 times the product of the square of the diameter (in centimeters) of the entrance pupil of the schematic eye and the lumi-

nance (in millilamberts) of the object which is focused on the fovea. Since four percent is a fair estimate of the loss by reflection at the cornea, the retinal illuminance expressed in lux can be taken as the product of the transmittance of the ocular media times the square of the diameter of the pupil (in centimeters) and the luminance (in millilamberts) of the object viewed.

A special unit of retinal illuminance, the photon, was introduced by Troland in 1917 and has been employed to some extent, but its use is circumscribed by the danger of confusion with the elementary quantum of radiant energy which is generally called the photon. The renaming of the unit of retinal illumination as the troland, in honor of Dr. L. T. Troland, its originator and chairman of the Committee on Colorimetry of the Optical Society of America in 1921-22, is recommended. In accordance with this suggestion the troland is defined as the retinal illuminance produced by luminance of one candle per square meter when the apparent area of the entrance pupil of the eye is one square millimeter. Data already expressed in photons should be expressed either in trolands, without the necessity for any numerical conversions, or they should be converted to lumens per square meter (lux) by multiplying the number of trolands by 0.00400 and by the transmittance of the ocular media. According to recent measurements, the transmittance of the media of the living human eye does not exceed 0.50 and decreases markedly with advancing age.

LUMINOUS REFLECTANCE

The concepts of luminous emittance and luminance are applicable to self-luminous surfaces and also to surfaces which are made luminous by diffuse reflection or transmission of luminous flux which is incident upon them. The luminous emittance of a reflecting surface is proportional to illuminance. When any consistent set of units is used the factor of proportionality for any surface, that is, the ratio of the luminous emittance to the illuminance of a reflecting surface, is its luminous reflectance. The luminous reflectance of a surface depends not only upon the nature of the surface but also upon the spectral distribution of the incident radiant energy and the relative amounts of the energy which are incident upon the surface from various directions. The luminous reflectance of a perfectly diffusing reflecting surface is independent of the spatial conditions of illumination. For such surfaces the luminance is also independent of the direction from which the surface is observed. The luminance of a perfectly diffusing reflecting surface is equal to its

luminous reflectance multiplied by the luminance of a perfectly reflecting, perfectly diffusing surface illuminated in the same manner.

DIRECTIONAL LUMINOUS REFLECTANCE

The luminance of an imperfectly diffusing surface may be compared with the luminance of a perfectly reflecting, perfectly diffusing surface which is similarly illuminated. The ratio of these luminances is a quantity which frequently differs from luminous reflectance. This ratio of luminances will be called directional luminous reflectance. The corresponding ratio of radiances of the surfaces, for homogeneous incident radiant energy and for the same spatial conditions of irradiation and observation, may be called directional spectral reflectance.

SPECULAR LUMINANCE REFLECTANCE

Directional luminous reflectance is not convenient for the specification of the reflectance of mirrors because of the inconveniently high values of this quantity measured in the direction of specular reflection of mirrors. Mirror surfaces are more conveniently specified by *specular luminous reflectance,* which is the ratio of the luminance of an object as observed by reflection in a mirror to the luminance of the object viewed directly.

LUMINOUS TRANSMITTANCE

Objects which transmit light without appreciable scatter are said to be non-diffusing. Objects which transmit light with appreciable diffusion are called diffusing. The luminous transmittance of any object is the ratio of the luminous flux transmitted by the object to the luminous flux incident.

DIRECTIONAL LUMINOUS TRANSMITTANCE

The luminance of a diffusely transmitting object is in general dependent upon the direction from which the object is viewed. A quantity analogous to directional reflectance may be useful for the specifications of such objects. This quantity may be called directional luminous transmittance, and may be defined as the ratio of the luminance (candle per unit area) of the second surface to the illuminance (lumen per unit area) of the first surface.

MEASUREMENT OF CHROMATICITY

In photometry chromaticity differences between samples and standards are sources of difficulty and error. In general, chromaticity differences between samples and standard cannot be eliminated in photometric measurements. The various methods of heterochromatic photometry are designed to minimize the noticeability of chromaticity differences, with-

out interfering with the determination of the relative photometric magnitudes. The measurement of chromaticity, on the other hand, is based on the adjustment of the chromaticity as well as the photometric magnitude of the standard until all visually apparent differences between the sample and standard are eliminated. The most accurate methods of colorimetry are those in which the noticeability of any residual chromaticity difference is greatest, and in which the physical specifications of the adjustable standard are determinable with the greatest accuracy. Chromaticity may be specified in terms of any optical arrangement which provides for the adjustment of the chromaticity of the standard. Specifications of chromaticity in terms of any one arrangement can be translated into terms of any other system of colorimetry by use of conversions based on the fundamental data which will be described. Dominant wave-length and purity are specifications of chromaticity in terms of a method of colorimetry which has been used very rarely in recent years. However, the results of more reliable, modern methods of colorimetry are very frequently converted into dominant wave-length and purity, and these specifications are usually preferred for the specification of chromaticity because colors are more readily visualized when specified in these terms. The dominant wave-length of a sample is the wave-length of spectrally homogeneous radiant energy which would have to be mixed with an appropriate amount of achromatic, or "white," light in order to match the chromaticity of the sample. The purity is an expression of the proportion of the spectrally pure component in the mixture matching the chromaticity of the sample. When the amounts of the components and the mixture are expressed in terms of luminance, this proportion is called colorimetric purity. Dominant wave-length and purity are rarely determined directly, but are usually computed from the results of other methods of colorimetry, such as the method of three-color synthesis.

THREE-COLOR METHOD OF COLORIMETRY

In the three-color method of colorimetry, each sample is matched with a mixture of three components of light having different chromaticities. The amounts (for example, luminance) of these components are independently variable. The chromaticities of the components are not variable, but may be selected initially so as to make possible the synthesis of a suitably large gamut of colors. The components employed in this system, called trichromatic colorimetry, are usually such that they can be described as red, green, and blue. The amounts of three components, of which the chromaticities are also stated, constitute a

specification of the color synthesized by the mixture of these three components. The chromaticity of the synthesized color may be specified in terms of the proportion of each of two of the components in the trichromatic mixture. These proportions are called *trichromatic coefficients.* Most samples can be matched by a suitable mixture of the three components. In this case, the amounts of the components are recorded as positive quantities. However, some samples of light cannot be matched with such a mixture of the three components. In most cases of this kind, it is possible to establish a match between a mixture of the sample light with one of the components and a mixture of the other two components. In this case, the amount of the component which is mixed with the sample light is considered to be a negative quantity. This quantity is subtracted from the sum of the amounts of the two components of the other mixture involved in the color match. The coefficients (proportions) of the components, which specify the chromaticity of the sample, are computed on the basis of this net total. The coefficient of the component which is mixed with the sample light is considered as a negative quantity, so that the algebraic or net total of the coefficients of the components necessary to establish the match is unity in all cases.

A series of examples will serve to clarify the procedures outlined above. A sample of "white" light such as daylight may be visually compared with a mixture of the three components (usually red, green, and blue). Any observer will find it possible to adjust the amounts of these three components in the mixture until it has exactly the same visual appearance as the sample of daylight. This procedure of adjusting the amounts until all visually apparent differences are eliminated is called color matching. The amounts of the three components of the mixture are recorded as positive quantities. These three quantities can be added together and the total divided into each individual amount in order to compute the coefficient of each component required for the color match. These coefficients constitute a specification of the chromaticity of the sample (daylight) in terms of the three components and for the observer who established the match. It is obvious that since the sum of the three coefficients is always unity, only two of them are necessary for the specification of the chromaticity.

If the daylight is passed through a yellow glass before the match is established, considerably less of the blue component will be required in order to establish the match. The amounts of the red and green components necessary for the match will be decreased somewhat, but the ratio of their amounts will be changed only slightly if at all. If the

yellow glass is very selective, daylight passed through it may be matched by a simple mixture of the red and green components. In this case no blue component is necessary for the match and the recorded amount of the blue component is zero. If the yellow glass is so selective that the purity of the light passed through it cannot be equalled by any mixture of the red and green components, then it is necessary to establish the match between a mixture of the yellow light with the blue component and a mixture of the red and green components. In this case, the amount of the blue component is considered to be a negative quantity, and is treated accordingly in the computation of the net total of the amounts of the three components, and the coefficients which specify the chromaticity.

In summary, when the purity of the yellow light increased, the coefficient of the blue component necessary for a color match decreased until finally for the purest yellow colors the coefficient of blue component necessary was less than zero, or negative. This negative coefficient is experimentally determined by establishing a color match between a mixture of the yellow with the blue and a mixture of the green with the red components. In a similar manner almost all colors having purities as high or nearly as high as the purity of light from narrow regions of the spectrum require negative coefficients corresponding to one of the components. Negative amounts and negative coefficients of components in color matching always refer to the establishment of a match by mixing the numerically specified amounts of the components with the sample light. In a few rare instances it would conceivably be necessary to establish the color match between one of the components and a mixture of the sample light with the other two components. Such would be the case if the green component were noticeably less pure than a similar green sample, or if the red component were noticeably yellower and less pure than a red sample, or if the blue component were noticeably less pure than a violet sample. The trichromatic components are usually chosen so as to minimize the occurrence of such cases. However, in such cases, the amounts and coefficients of the components which are mixed with the sample are both considered to be negative.

INDIVIDUAL VARIATIONS OF COLOR-MIXTURE CURVES

Since there is such a close connection between the luminosity curve and the color-mixture curves, variations similar in magnitude to the observed variations in luminosity curves must be expected between the color-mixture curves for different observers. Furthermore, the effects of

selective absorption in the media of the eye and in pigmentation which occurs locally in the retina are variable from one observer to another. Such variations, which may be detected by the well-known "yellow-blue" ratio and "red-green" ratio tests, result in wide variations of the color-mixture curves for different observers.

STANDARD COLOR-MIXTURE DATA

The averaged results of two independent investigations of color-mixture curves for a total of seventeen observers have been expressed in units consistent with the standard luminosity curve and adopted by the International Commission on Illumination in 1931. The color-mixture curves which were adopted correspond to hypothetical standard stimuli, one of the standard color-mixture curves being identical with the standard luminosity curve, the other two color-mixture curves having no negative values. The ordinates of the standard color-mixture curves are expressed in arbitrary units such that the areas under all three curves are equal when the data are plotted to equal scales.

Experimental curves consistent with the standard color-mixture curves are found only by rare observers. Such observers can be identified only by selection from a large group of observers, for all of whom color-mixture curves have been determined. Because such a survey of observers is quite impractical, the use of actual observers equivalent to the standard observer for the direct visual determination of standard colorimetric specifications is impractical. The standard color-mixture data can be used for the computation of standard photometric and colorimetric magnitudes. Such computations are based on spectroradiometric and spectrophotometric data. This indirect method of colorimetry is quite practicable, and the computation of standard colorimetric specifications from spectroradiometric and spectrophotometric data is used extensively.

SIGNIFICANCE OF STANDARD DATA FOR NON-STANDARD OBSERVERS

Specifications computed by indirect colorimetry permit the classification of ordinary colors in manners corresponding very closely to the appearance of the colors for over ninety per cent of the population. The considerable differences which can be detected in the color mixture curves for different observers are not sufficient to cause more than ten per cent of the population to become aware of any inconsistencies of classifications of ordinary colors based on the standard color-mixture data. About five per cent of the population have color vision which is classified as definitely anomalous, since their differences from "normal" observers can easily be detected by the use of simple "color blindness tests." The

classifications of color based on standard color specifications are usually more complex than anomalous observers consider appropriate. Exceedingly few anomalous observers insist on any essential rearrangement of the standard classifications. Arrangements of colors made by observers with anomalous color vision usually consist of random and unreproducible rearrangements of colors within certain of the groupings defined by the standard data. Such unreproducible rearrangements are evidence that the observers cannot distinguish, and therefore confuse, the colors within these groups which a normal observer can distinguish and arrange.

COLOR-MIXTURE DATA ARE INDEPENDENT OF ALL THEORIES OF COLOR VISION

Theories of color vision purport to explain the phenomenon in terms of retinal structure and function, nerve action, and cerebral projection. Color-mixture data on which are based computations of color specifications are independent of all theories of color vision. Discussions of colorimetry are frequently confused by the association of color-mixture facts with the earliest modern theory of color vision, that of Young and Helmholtz. In reality, the laws and data of color mixture are completely independent of any theory, and no reference need be made to any theory of color vision in expositions of the science of colorimetry. On the other hand, no theory of color vision merits consideration which does not fully and accurately account for the facts of color mixture. The Young-Helmholtz theory is commonly linked with the color-mixture data because it accounts for the color-mixture curves in the most straightforward manner. Such simplicity is no guarantee of correctness, however, because other more elaborate theories also consistent with the color-mixture data have been devised.

TRISTIMULUS VALUES

The tristimulus values of any sample of light are defined as the magnitudes of the three standard stimuli computed to be necessary in a mixture matching the light. It is necessary to specify the units in which these tristimulus values are expressed. This can be done by stating in the same units the tristimulus values for some standard or physically defined sample.

COMPUTATION OF TRISTIMULUS VALUES OF ANY COLOR

Each of the three tristimulus values of a sample of radiant energy may be computed by integrating the product of the ordinates of one of the standard color-mixture curves multiplied by the energy in the corresponding wave-length regions of the spectrum of the sample of radiant

energy. If the sample of radiant energy is that reflected from a surface, the spectral composition of the reflected energy is of course given by the products at each wave-length of the spectral composition of the incident energy and the corresponding directional radiant reflectance of the surface. This product can be employed as the spectral composition of the reflected energy in the calculation of the tristimulus values of the color of the light reflected from the surface. It is customary to express the tristimulus values of reflected light in units such that the tristimulus value resulting from the integration with the luminosity curve is numerically equal to the directional luminous reflectance of the surface for the spectral distribution of radiant energy assumed in the calculations.

The tristimulus values of transmitted light are computed and expressed in similar fashion.

The integration may be carried out by use of the ordinary methods of numerical integration. Special methods have been devised to facilitate the calculations of tristimulus values of the light reflected and transmitted by objects illuminated with light from the most frequently encountered sources.

SPECIFICATION OF CHROMATICITY IN CHROMATICITY DIAGRAM

Chromaticity can be specified by use of the proportions which two of the tristimulus values bear to the total of the three tristimulus values. These two proportions can be employed as coordinates for the representation of the chromaticity of a sample by the position of a point in a plane diagram. Such a diagram is called a chromaticity diagram. In particular, the chromaticity of each spectrum color can be computed by dividing the ordinate of each of the color-mixture curves at the appropriate wave-length by the sum of the ordinates of the three curves at that wave-length.

DESCRIPTION OF COLOR MIXTURES IN TERMS OF CHROMATICITY DIAGRAM

The tristimulus values of a mixture of several varieties of light are the sums of the corresponding tristimulus values of the components of the mixture. It follows from this fact that the point representing the chromaticity of a mixture of two components is located on the straight line connecting the points representing the chromaticities of the separate components. The point representing the chromaticity of the mixture is the center of gravity of a system of weights proportional to the sums of the tristimulus values of each component. These weights are located at the points representing the components of the mixture.

The purest non-spectral colors are represented by points on this straight line connecting the extremities of the spectrum locus. Less pure non-spectral colors are represented by points lying closer to the achromatic point. Colors represented by points on straight lines between the achromatic point and the spectrum locus will be called spectral colors. The spectrum locus, together with the straight line joining its extremities, may be called the boundary of real colors.

ACHROMATIC STIMULI

An alternative numerical system for specifying chromaticity is based on the position of the point representing chromaticity in the diagram. The use of this system of specification requires a decision as to what kind of light will be said to have zero purity, that is, what kind of light shall be considered achromatic. Since the specification of chromaticity which is based on this decision has reasonableness of correlation with ordinary color description as its chief merit, the choice of the achromatic stimulus should always be such as to yield the most reasonable specifications. In most ordinary circumstances, the chromaticity of the prevailing illuminant is a satisfactory choice for the achromatic stimulus. For brevity, the point representing the achromatic stimulus may be called the achromatic point. Similarly, the point representing the sample may be called the sample point.

DOMINANT WAVE-LENGTH AND PURITY

When the achromatic stimulus has been decided upon, the chromaticity can be specified in terms of dominant (or complementary) wave-length and purity. The *dominant* wave-length of a spectral color is the wave-length associated with the point on the spectrum locus which also lies on the extension of the straight line drawn through the sample point from the achromatic point. In the case of non-spectral colors, the line drawn in this manner does not intersect the spectrum locus. In this case the chromaticity is specified by *complementary* wave-length and purity. The complementary wave-length is defined as the wave-length associated with the point on the spectrum locus which also lies on the straight line drawn from the sample point and extended through the achromatic point. The purity of any sample of light is determined by the distance of the sample point from the achromatic point. The purity is equal to this distance, expressed as a fraction of the distance between the achromatic point and the intersection of the boundary of real colors with the line drawn from the achromatic point and extended through the sample point.

It is permissible and sometimes desirable to determine purities based on chromatic rather than achromatic reference stimuli. Anomalous expressions can be avoided in such cases by substituting the terms *reference stimulus* and *reference point* in place of the more specific terms, achromatic stimulus and achromatic point.

INTERPRETATION OF CHROMATICITY DIFFERENCES

Although specifications of colors are easily interpreted in terms of dominant wave-length and purity, a supplementary specification of the kind and degree of chromaticity difference is sometimes convenient. The kind of chromaticity difference between a sample and a reference stimulus may be specified by the wave-length (or complementary wave-length) corresponding to the point at which the straight line drawn from the reference point and extended through the sample point intersects the boundary of real colors. This wave-length has been named *conjunctive wave-length*. The degree of color difference may be specified by the purity of the sample computed with respect to the reference stimulus. This specification of a chromaticity difference supplements, but does not replace the specifications of the two colors in terms of dominant wave-length, purity, and luminance.

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IMPROVEMENT INDICATED IN THE GENERAL TONE OF OPTOMETRIC PRACTICE

Generally speaking, the large urban centers are supposed to contain the worst commercial elements in optometry. In our larger cities are frequently found the chain store operator, the optical department and the individual who advertises the fact that he is engaged in the practice of visual care and that he both makes and repairs glasses. Of course, not all offenders are in large cities and by no means are all optometrists who practice in large cities offenders. Many of our most outstanding optome-

trists conduct their professional practices in urban centers, yet the level of "large city practice" is frequently criticized when optometrists gather at sectional meetings.

The offenders mentioned do much to degrade optometry in several ways, one of which is their constant use of display space in the local newspapers. These advertisements not only hold up the individual advertiser as a man lacking in good taste and professional ethics but also detract from the public's estimation of all members of his profession. The number of these ads in the past in the large metropolitan papers has been considerable. Recent studies indicate, however, that there is a marked decline in the use of this media by optometrists. This decline is a very healthful sign.

As an illustration of this decline in the use of display space by optometrists, we present a breakdown by classification of all "health" ads appearing in the Sunday issue, September 24, 1944, CHICAGO TRIBUNE, the self-acclaimed "World's Greatest Newspaper." The accompanying table presents each group of advertisers in the order of the number of "lines" of copy run. There are 14 lines to the display inch, single column.

Classification of Advertiser	Number of Advertisements	Total Number of Lines of Copy Run
Patent Medicine	18	2065.0
Hearing Aids	4	1078.0
Physicians (M.D.)	1	770.0
Medical Appliances	5	248.5
Oculists	1	119.0
Optometrists	1	112.0
Totals	30	4392.5

This table is not without its significance. It indicates, for instance, that of the health advertising run in this large urban paper on that date, that less than 4 per cent of the lineage utilized was inserted by an optometric advertiser. It indicates also that of the several hundred practicing optometrists in Chicago, only one* purchased space in that large issue. A number of rather "salty" intra-professional comments could be made as the result of this table but the writer will leave these to his individual readers.

*The hearing aid advertisements were inserted by advertisers who were not optometrists.

What is really of importance is this—that optometrists are, in general, improving the tone of their practices. The work is by no means complete, but good progress is being made. As these needed reforms take place our profession moves forward towards its rightful place of high standing among the arts and sciences of America.

CAREL C. KOCH.

BOOK NOTICES AND REVIEWS

Books received are acknowledged by notices in this department. Special selections will be made for more extensive review in the interest of our readers as space permits.

TECHNIQUE OF FITTING CONTACT LENSES, Albert L. Anderson. Published by McGill Lithograph Company, Minneapolis, Minn. 55 illustrations and 4 color plates, 71 pages. Cloth 1944.

This interesting book was written by Mr. Albert L. Anderson who is part owner of Precision Contacts and Director of the Scientific Department of the N. P. Benson Optical Company, Inc., of Minneapolis, Minn. Most of the illustrations are large, clear photographic plates and the reader will appreciate the four colored illustrations of the perfect and imperfect fitting lens under white light and the fluorescein test. The material is compact, clear and illuminates the technical difficulties of adapting contact lenses with practical experience. This little book will be of interest and value to any optometrist who desires to know more about contact lenses.

C. W. MORRIS.

LIGHT, VISION AND SEEING, Matthew Luckiesh, D.Sc., D.E. Published by D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York City, N. Y. 323 pages, 83 illustrations and 16 plates. Cloth. $4.50. 1944.

The author is the Director of the Lighting Research Laboratory of the General Electric Company at Nela Park, Cleveland, Ohio. Since 1915 the author has written some twenty-two books dealing with different phases of light and vision. Dr. Luckiesh is committed to the development of seeing as a science as distinguished from the science of vision. He successfully establishes the fact that the percentage and degree of eye defectiveness and eyestrain can be reduced by manipulation of the factors of size, contrast, brightness and time.

The presentation of the fundamental facts in this book is simple but combined with practical discussions which are useful to the optometrist, particularly when his interest in the visual problems of his patients extends to the use of their eyes at home or in the factory or office. For the optometrists whose interests are directed to research problems in this field two additional books by the author are recommended. These two references are THE SCIENCE OF SEEING (1937) and READING AS A VISUAL TASK (1942).

We recommend this book to the optometrist as an excellent reference book for all questions involving the external factors in seeing. The science of seeing as developed by Dr. Luckiesh should constitute one of the essential subjects in the optometric curriculum. This subject matter would lend itself very easily to development of a most interesting course in extension work for the practicing optometrist.

C. W. MORRIS.

TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

by J. Fred Andreae, Secretary

A department devoted to announcements, reports, appointments, organization data, news professional problems and ideals, as these relate to the Academy.

AMERICAN ACADEMY CONVENTION

December 10, 11, and 12 are but a short time away. Those of you who have hesitated to commit yourselves on attending the convention are asked to note well the program as listed below. It is one that for interest and information should be outstanding.

The balance between those who have previously appeared on our programs and new speakers is well preserved. To have added these speakers in these times speaks well for the growth of the profession.

In addition to our regular program, there will be a "Symposium on Optometric Education." This is an open forum to which all of the Fellows in attendance should contribute.

HOTEL STEVENS
Chicago, Illinois
December 10, 11, 12, 1944

OFFICIAL PROGRAM

Opening Session
SUNDAY, 10 A. M., DEC. 10, 1944
Dr. A. P. Wheelock, *President*, Presiding
Des Moines, Iowa

PRESIDENT'S ADDRESS
Dr. J. Fred Andreae, *Secretary-Treasurer*
Baltimore, Md.

ANNUAL REPORT
Dr. Dan G. Hummel, *Program Chairman*
Cleveland, Ohio

LUNCHEON RECESS

1:30 P.M. *"Myopia"*
Dr. Charles Sheard
Mayo Foundation
Rochester, Minnesota

2:00 P.M. Discussion

2:15 P.M. *"The Use of Complex Numbers in the Designation of Ophthalmic Prisms"*
Dr. Mathew Alpern
U. S. Army

3:00 P.M. Discussion

3:20 P.M. *"On Astigmatism"*
Drs. R. E. Bannon and Rita Walsh
Dartmouth Eye Institute
Hanover, New Hampshire
Part I "Historical"
Dr. Walsh

4:00 P.M. Discussion

4:20 P.M. Part II *"Limitations of Objective Tests"*
Dr. Bannon

5:00 P.M. Discussion

DINNER RECESS

7:30 P.M. Part III *"Subjective Tests, Distance and Near"*
Dr. Walsh

8:10 P.M. Discussion

8:30 P.M. Part IV *"Further Considerations of Clinical Importance"*
Dr. Bannon

9:10 P.M. Discussion

MONDAY, DECEMBER 11TH.

9:00 A.M. *"Let Us Seek Truth"*
Dr. Laurence P. Folsom
South Royalton, Vermont

9:30 A.M. Discussion

9:45 A.M. *"Astigmatic Accommodation, A Case Report"*
Dr. Henry Hoffstetter
School of Optometry
Ohio State University
Columbus, Ohio

10:05 A.M. Discussion

10:15 A.M. *"An Eye Correction-Protection Program in Industry"*
Dr. Richard Feinberg
Supervisor, Eye Service Section
Sperry Gyroscope Co., Inc.
Long Island, New York

11:15 A.M. Discussion

LUNCHEON RECESS

1:30 P.M.	*"The Dependence of the Pupil Size on Accommodation and Convergence"* Dr. Glenn A. Fry School of Optometry Ohio State University Columbus, Ohio
1:50 P.M.	Discussion
2:00 P.M.	*"Disturbances of Photopic and Scotopic Adaptations and their Clinical Significance"* Dr. Charles Sheard Mayo Foundation Rochester, Minnesota
2:30 P.M.	Discussion
2:50 P.M.	*"Squints"* Dr. F. A. Seifert Detroit, Michigan
3:20 P.M.	Discussion
3:40 P.M.	*"Depth Perception in Relation to Monocular Variations in Visibility"* Dr. R. S. Jordan Cleveland, Ohio
4:00 P.M.	Discussion
4:10 P.M.	*"The Phenomenon of the Tilting Field as Found in Clinical Practice"* Dr. R. M. Hall Cleveland, Ohio
4:30 P.M.	Discussion
	RECESS
7:30 P.M.	BANQUET *"National Registration and Reciprocity for Optometrists"* Dr. Carel C. Koch Minneapolis, Minnesota

TUESDAY, DECEMBER 12TH.

9:00 A.M.	*"Light, Vision and Seeing"* Dr. Matthew Luckiesh Director, Lighting Research Nela Park Cleveland, Ohio
10:00 A.M.	Discussion
10:30 A.M.	*"Trends in Education"* Dr. Lewis H. Kraskin Washington, D. C.
11:00 A.M.	Open Discussion *"Symposium on Optometric Education"*
	LUNCHEON
1:30 P.M.	*"Symposium on Optometric Education"*

The program committee takes pride in presenting this program of the annual meeting of the Academy. All members are urged to attend and take part in the discussion periods. Reservations for hotel accommodations in Chicago should be made at once. This also applies to reservations for train travel as both are difficult to secure on very short notice.

D. G. HUMMEL.

ANNOUNCEMENTS

CONFERENCE ON CONTACT LENSES

A Contact Lens Conference was held at the Palmer House in Chicago on October 13th. This conference was attended by ophthalmologists, optometrists, opticians, technicians and manufacturers.

The following papers were presented: Future of Contact Lenses, Philip L. Salvatori; Selection of Contact Lens Patients, Hugh L. Hunter; New Developments in Molding Technique, Albert L. Anderson; Observations in a Large Material of Contact Lens Patients, Allan Rossby, M.D.; The Physical and Physiological Chemistry of Contact Lens Solutions, Robert J. Roth, M.S.; History of Contact Lens Solutions, Harry Hind; New Casting Shell, Philip L. Salvatori; Technique of Fitting Contact Lenses as Related to the Anatomy of the Eye, Americo Oriani; The Science of Fitting, Philip L. Salvatori; Elimination of Bubbles and Tightening a Loose Periphery, Philip L. Salvatori; Contact Lenses in Aphakia, Ewing Adams, O.D., D.O.Sc.; Induced Astigmatism with Contact Lenses, Theo. E. Obrig, A.B.; Cover Test in Fitting of Contact Lens, Ralph Lowry; Contact Lenses in Argentina, Eduardo Amoretti, M.D.; Unity of the Specialist as Well as the Profession, William Sneider.

Complete transactions of this meeting are being prepared[1] which will be available at cost to anyone interested in contact lenses. A special committee will meet on November 18th in New York City for the purpose of formulating a contact lens society.

[1] Theo. E. Obrig, Obrig Laboratories, Inc., 49 East 51st Street, New York 22, N. Y.

AMERICAN OPTOMETRIC LEGION

During October, 1944, a committee of the American Optometric Legion met in Philadelphia to discuss the difficulties and problems of optometrists now serving as refractionists in the army of the United States. Also discussed were methods of improving the status of army optometrists, professionalism, education and social health recognition.

News that the American Optometric Association was in the process of developing a bill to present to congress was discussed. It was felt that such a bill should be designed forcefully and presented in the light that optometry was now a profession, recognized at law in all states and that its practitioners should therefore be given the recognition ac-

corded members of other professions serving in the army.

The committee felt that since the conciliatory attitude of the past several years had brought forth only varied promises and false hopes that the officials of the American Optometric Association recognize that the entire problem now demands a fighting spirit, one worthy of the founders of the optometric profession and one which shows faith in the future of our profession.

The committee also took the position that the bill must recognize and include all optometrists. It must not provide only token recognition. Such a bill would merit the support of the entire profession.

N. A. ZEVIN.

ABSTRACTS

A department in which will appear abstracts of the literature of optometry, ophthalmology and applied optics. These will be classified according to the following list, although contributions to all sections will not necessarily appear in each issue.

1. Ocular Refraction.
2. Physiological Optics and Color Vision.
3. Ocular Muscles.
4. Orthoptics and Reading.
5. Anatomy, Histology and Embryology.
6. Ocular and General Pathology.
7. Ophthalmic Lenses and Material.
8. Instruments.
9. Hygiene and Illumination.
10. Applied and Physical Optics.
11. Education, Sociology and Economics.
12. Miscellaneous.

1. OCULAR REFRACTION

AMBLYOPIA AND VISUAL TRAINING. J. I. Pascal. Optical World. 1944, 32, 2, 15.

It is well established, claims Pascal, that persistent visual training of an amblyopic eye will often improve vision to an astounding degree. Vision of 20/70 or less can in many cases be brought up to normal 20/20. But it is also well known that many amblyopic eyes do not respond to visual training and the improvement, if any, is negligible. There is evidently some factor or factors in the fovea or further back which determine the success or failure of visual training of the fovea. There has been no reliable test available for differentiating the cases that would respond to training and those which would not.

Recently, such a test was presented by a New York eye specialist who claims to have found it very reliable in differentiating the amblyopic cases which would respond to treatment from those which would not. The basis of the test is an old entoptic phenomenon known as Haidinger's tufts and described by Haidinger one hundred years ago. If you look through a Nicol prism or any polarizing device, say a piece of polaroid, at the sky you will see a distinct, though faint, cross. The

appearance is more striking if the piece of polaroid is rotated while looking through it. The cross has the form of a Maltese cross with widened, fluffy extremities and has one limb yellow and the other limb blue. It rotates with the rotation of the polaroid glass.

According to Pascal, the specialist who presented the test claims in essence that any one who can see the cross has a healthy fovea. In such cases, if foveal vision is sub-normal, it can be developed by visual training. But if one cannot see the cross, it shows that the fovea is defective and no amount of visual training will improve it.

T. O. B.

CORRECTIONS FOR APHAKIC EYES. R. W. Tubesing. Indiana Optometrist. 1944, 16, 6, 6-7.

This paper deals with high power lens effectivity and the manner in which this is taken into consideration in prescribing for aphakia. Tubesing brings out one new fact in this paper and this is that many cases of aphakia have also a vertical phoria which should be corrected by base-up of down prisms to give the patient as much comfort as possible.

A. V. F.

A STUDY OF THE OPTOMETRIC Rx. M. A. Endore. Optical World. 1944, 32, 4, 18-21.

The author comments on record charts and some of the findings of a refraction which should be recorded during each examination. Failure to record these data makes the chart of less value for various future uses. The points stressed by Endore which are sometimes omitted are as follows: (1) the uncorrected monocular visual acuity. (2) The P.D. of each eye separately, taken from the center of the bridge of the nose. (3) The uncorrected, corrected and relieved amount of phoria when present in quantity. (4) The distance the lenses are to be placed from the eyes in the finished correction. (5) The amount of angling to be given the lenses in the finished correction. (6) The final corrected visual acuity of each eye as well as of both. (7) The near-point P.D., and the (8) decentration, if any, to be incorporated in the correction when finished.

C. C. K.

NEWER CONCEPTS OF EYE STRAIN. E. E. POOS. Eye, Ear, Nose and Throat Monthly. 1944, 23, 3, 107-110.

Eye strain is a most common symptom and condition. The eye,

although a prolongation of the brain, is developed embryologically from ectoderm and mesoderm, so that by examining the organ one can diagnose the affections of mesodermal and ectodermal derivatives in other parts of the body and especially of the brain. Just as by fundus examinations the eye has a tendency to evidence the general health from an organic standpoint, it also manifests the functional reaction of the patient to emotions, fatigue, and the like. It may, therefore, react to the general health of the individual by various reflexes or due to disorders of its neuro-muscular apparatus may cause various reflexes in various parts of the body, or may be part of a general syndrome showing the general state of health of the individual.

As a result of this condition, the general practitioner often does not recognize the importance of an eye examination except when the patient complains of poor vision, while the refractionist sometimes is inclined to attribute many symptoms to eye strain or an error of refraction. As a result, the patient is given a new pair of glasses, possibly with a slight change from a previous pair, when most of his trouble is constitutional or of emotional origin. Too often a diagnosis is made that the patient is neurotic, thus closing the case.

Many refractionists pay much attention to squint cases, although very few of these complain of eye strain. Few squint cases, according to Poos, have binocular vision, generally using one eye for vision, and to avoid diplopia, one eye becomes amblyopic, so that often the muscles are operated on with a good cosmetic result, but unless exercised by orthoptics, the patient still does not have binocular vision while the patient with neuro-muscular anomalies is neglected. These patients often go from one refractionist to another, each changing the prescription slightly.

Several factors contribute largely to this failure in rational treatment. From the symptoms offered by the patient, Poos points out, eye strain may not easily be suspected, for many of these seem to have little or no relation to an ocular origin. Further, in a great many cases the vision as judged by the patient's own standard may be unimpaired or indeed may be considered even above the normal. But often small refractive errors may give considerable distress due to the patient trying to rectify these by neuro-muscular effort which finally brings about a state of muscular or nervous fatigue. When a gross anomaly exists and vision is blurred and indistinct, the visual apparatus adapts itself to its disability without any attempt to improve its underlying condition. The condition thus begins and ends with an impairment of vision, the diag-

nosis is apparent and the treatment obvious, for these cases often do not have much eye strain, only poor vision. However, claims Poos, small errors often cause eye strain through the constant effort called forth in an attempt to correct the error, so that on examination we find only a small error of refraction but considerable neuro-muscular anomalies.

The ocular symptoms associated with eye strain are directly due to the increased muscular work which the defect invokes and the discomfort of the resultant fatigue, to which is added the effects of more or less vascular engorgement brought about by this sustained and forced activity. Subjectively, especially after long periods of close application to work, the eyes feel tired, hot and uncomfortable; temporary relief is obtained by resting or rubbing them, but if the work is persisted in, the vague discomfort gives place to a sense of actual strain, and this develops into pain. Pain in the eyes unconnected with inflammation is almost invariably due to eye strain and rarely to any deep seated disease, says Poos. It usually is mild, dull and aching, but may be severe and acute; it may be situated in the eyes themselves or deep in the orbits, spreading from them and referred to as a general headache. Objectively, the eyes frequently have a typical appearance. The continued state of irritability and congestion brings about an unhealthy condition of the lids and conjunctiva. Blepharitis and recurrent styes are common, and low grade infections of the conjunctiva readily establish themselves and tend to become chronic in spite of the usual medicaments. The eyes have a characteristic watery, suffused and bleary appearance.

Eye strain, claims Poos, is a very prevalent symptom, often taxing our skill in its proper analysis and treatment. Eye strain often reflects the general health of the patient. There are several important steps in the diagnosis based on a properly taken history. The therapy includes correction to improve vision, balance accommodation and convergence to obtain binocular vision and fusion by glasses, prisms, exercises and proper attention to the general health of the patient and hygienic advice.

T. O. B.

TRANSITION FROM CORNEAL TO CILIARY ASTIGMATISM.

C. W. Morris. Indiana Optometrist. 1943, 15, 8, 5-7.

Morris presents a case report which shows the transition from a known and determined corneal astigmatism, with the rule, to a total senile ciliary astigmatism, against the rule. This change was observed

over a two months period in the right eye of a female patient age fifty-six.

A. V. F.

NOTES ON PRESCRIBING. C. H. Sadler. Optician, (London). 1942, 104, 2695, 253-254.

"Generally speaking, I believe that discomfort brings people to us in a greater proportion of cases than does poor vision. Many ametropes of even high degree do not seek our advice except when their errors interfere with their work and livelihood and in such circumstances they have no alternative. The deep-rooted aversion to glasses which persists despite many laudable attempts to glamourize spectacle-ware accounts for this to a great extent. We are always up against a certain amount of hostility, particularly among the younger generation, and share with the dentists the unenviable reputation of 'always finding something wrong.' From my own experience, the truth is that we rarely refract a person who does not require a correction, at least for close work. The very fact of their seeking our advice shows that something *is* wrong and needs correction."

T. O. B.

THE CORRECTING LENS IN MONOCULAR APHAKIA. J. I. Pascal. Optical World. 1944, 32, 1, 16-17.

Pascal points out that patients with monocular cataract, who have good serviceable vision in the other eye, are generally better off when not operated upon. The reason for this being that after the operation the optical systems of the two eyes are so different as to make binocular vision very difficult.

If an operation must be performed, Pascal suggests several ways to overcome the binocular visual problem confronting the patient. (1) A telescopic spectacle lens before the operated eye; this lens made with a negative objective and a positive ocular, to reduce the size of the retinal image. (2) A contact lens made for the operated eye, to have the same effect in reducing the size of the retinal image. (3) A frosted lens over the eye with poorer vision to prevent diplopia. (4) A non-correcting 5 △ or 6 △ prism, base-up or down before the poorer eye to prevent diplopia and to cause the eye to suppress. Pascal indicates that the latter method is to be preferred as the cosmetic aspect must also be taken into consideration.

A. V. F.

VISUAL SKILLS. C. F. Shepard. Optometric Weekly. 1944, 34, 51, 1465-1466.

"When optometrists are requested to assist in finding visual difficulties which may account for industrial or academic failures, the first thought is likely to be concerned with some method for discovering so called 'errors of refraction'; but, in spite of the many surveys and several properly conducted studies, nothing has yet been published to show relationship between uncorrected ametropia and failure to achieve in the worlds of labor and learning.

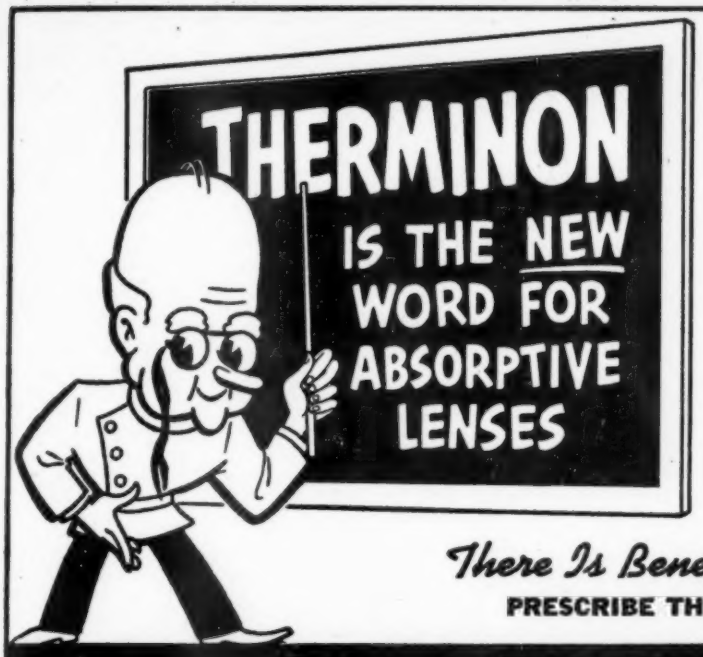
"It is admitted that when extremes of ametropia are found, a critical condition may exist, and that great improvement may follow, but such cases constitute no more than 5 per cent of the total. The proportion is far too small to be of great importance in the fields where the study of visual skills is being found of real value.

"So far investigators have found what optometrists call four visual skills related to achievement in work and study. These are: visual acuity, phorias, stereopsis, and color vision. In general optometry recognizes about 20 distinct visual skills, and the list may be made longer by further study and subdividing. Undoubtedly, as time goes on there will be discovered significant relationships between specific tasks and certain visual skills. Indirect vision, as demonstrated in the measuring of form fields, is already recognized as of importance in contributing to safety; but a satisfactory technique is lacking. Speed (or span) of visual perception has been found significant of certain special abilities and attention to it may be extended greatly in the future. But for the present it is important that optometry recognize the significance of the relationships between these four visual skills and achievement in the every-day world."

1944, 34, 52, 1493. T. O. B.

MYOPIA AND STATISTICS. T. G. Atkinson. Optometric Weekly.

Atkinson doubts the current explanation given by those who support the "functional" theory of myopia. He believes that certain physical deficiencies play an important part in the development of myopia and suggests that more attention be given to this phase of ocular refractive research. C. C. K.



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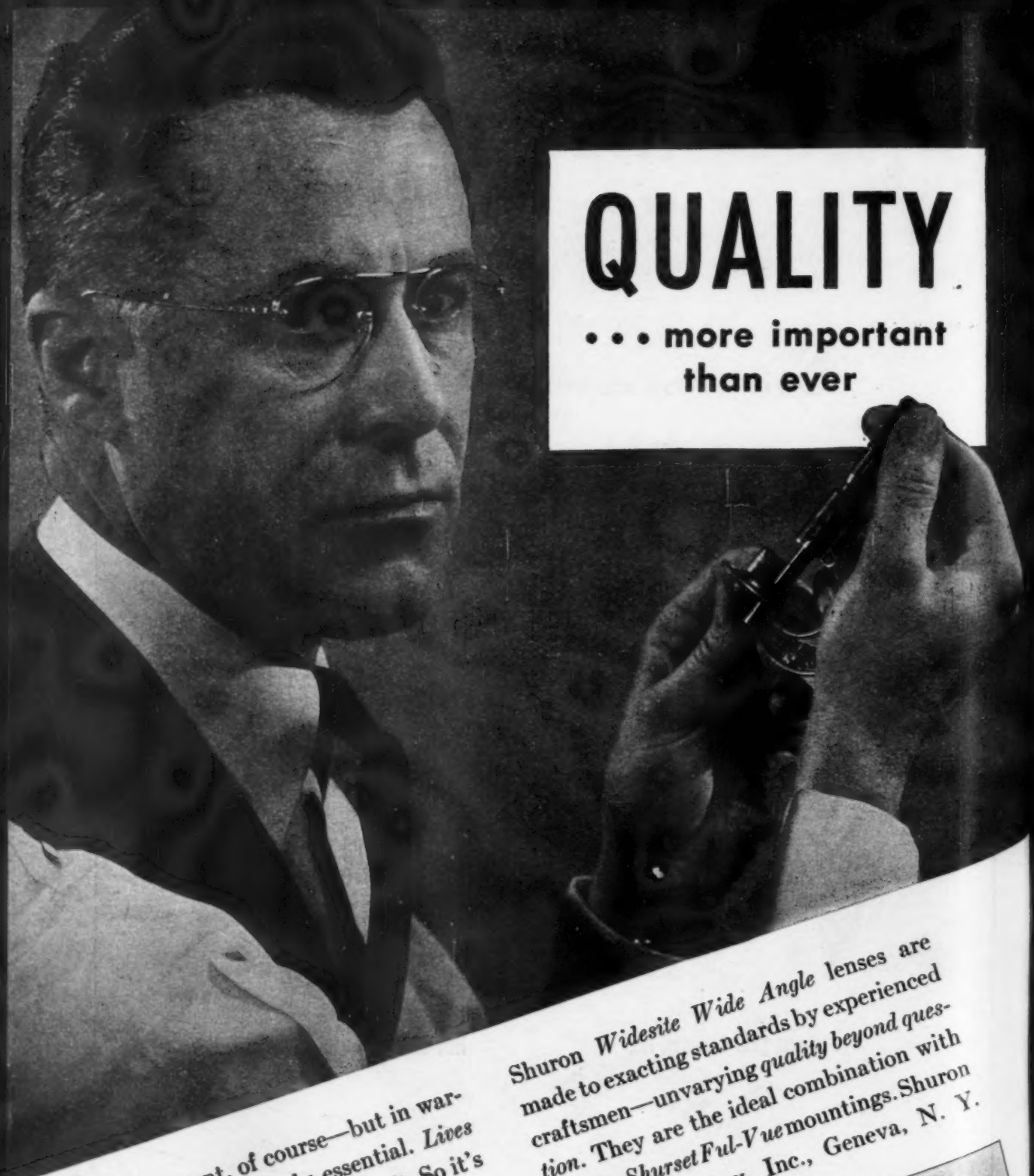

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